Impacts of livestock management and climate variability on carbon storage and GHG emissions of mountain grasslands
Katja Klumpp

To cite this version:
Katja Klumpp. Impacts of livestock management and climate variability on carbon storage and GHG emissions of mountain grasslands. Global Research Alliance, Feb 2011, Clermont-Ferrand, France. hal-02802216

HAL Id: hal-02802216
https://hal.inrae.fr/hal-02802216
Submitted on 5 Jun 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
Agricultural practice versus climate variability - Measurements of GHG emissions over grazed grassland

Katja KLUMPP
Grassland Ecosystem Research, Clermont Ferrand
Permanent upland grassland site
Laqueuille (alt. 1050m)

**Infrastructure**
- 2008-2012
- 2007-2011

**Projects**
- 2010-2013
- 2009-2013
- 2008-2011
- 2005-2008
- 2003-2005

Flux tower network

25-50 sites
Free Troposphere

Stratosphere Boundary layer altitude (km)

CO₂/CH₄ Column density from space

Avions

Super-sites

Satellites

Boundary layer sampling

Ecosystèmes

CO₂/CH₄ Column density from ground

Boundary layer sampling

Spectral reflectances, surface biophysics

Surface flux density
Definition of C sequestration in grassland

Net C sequestration
(Net ecosystem exchange = C inputs - C outputs)

Photosynthesis (uptake CO₂)

- Respiration plant

- Respiration soil

Respiration ecosystem

+ Slurry Manure

+ Respiration plant

+ Growth

+ Ingestion

- Faeces

Residuals cultures

Carbon Stock

CH₄
Permanent upland grassland site F-Laquoteille
Alt. 1050m, mean T 8°C, 1000mm

Set up in May 2002
Grazed May-October

**Intensive**
1 LSU ha.yr-1
210 g N ha.yr-1 (3 splits)
13.7 % clover

7 dominante species (36)
Prod: 7.1t DM green.ha.yr-1
Standing: 2.6t DM.ha.yr-1

**Extensive**
0.5 LSU ha.yr-1
4.4 % clover

7 dominante species (31)
Prod: 5.1 t DM green.ha.yr-1
Standing: 2.2 t DM.ha.yr-1
Experimental Setups

EXTENSIVE 3.84 ha

INTENSIVE 2.82 ha

Flux Tower
CO₂ + CH₄

Flux Tower

DOC/DON

Meteo
station

DOC/DON

Flux
tower

N₂O

Grazing exclusion cages (n=10)

Automated chambers for N₂O (n=8)
Grazing exclusion cages (n=10)
Biomass production
Productivity

Annual plant community observations (n=5)
• Botanical composition
• Plant functional traits
• Shoot: SLA
  LDMC
  LNC
• Root: Specific root length
  Root tissue density
  Diameter
• PAR
• Plant heights
• Phenology Images

• Soil inventory 2004, 2008, 2011/12
Eddy-covariance:
Open path IRGA LI7500
+
Sonic anemometer 3D

Flux towers: Spatial scale ≈ 1ha - 1 km²
Both paddocks are a sink of C (negative NEE)
Cumulated NEE (6 yrs) was 12.5 et 14 t C ha\(^{-1}\) for the extensive and intensive paddock
Inter-annual variability of NEE
2004, 2006 et 2007 = EXTENSIF
2003, 2005 et 2008 = INTENSIF

Klumpp, Tallec, Guix & Soussana (2011) en preparation
Inter-annual variability of precipitation

Seasonal variability of precipitation to 30 yrs mean (%)

Seasonal variability of soil water content (0-40 cm)
Inter-annual variability

Number of weeks with low soil water content (< 28%)

Fixation and Respiration (Reco) during dry and wet weeks

**Dry weeks**
Low SWC

- Fixation extensive > intensive
- Reco extensive = intensive

**Wet weeks**
High SWC

- Fixation extensive = intensive
- Reco extensive < intensive

Inter-annual variability of NEE

- **Wet years** (2004, 2006 and 2007)  EXTENSIVE > INTENSIVE
- **Dry years** (2003, 2005 and 2008)  EXTENSIVE < INTENSIVE
Conclusion:

Agricultural practice directly affected vegetation cover and soil properties, which in turn indirectly affected soil drying and C-fluxes.

Under wet conditions (net C sequestration > extensive)
- intensive paddock, high heterotrophic respiration due to a higher turn over of vegetation cover
- extensive paddock, low heterotrophic respiration due to substrat limitation (C and N) and less « palatable » plant tissu ».

Under dry conditions (net C sequestration > intensive)
\[\Rightarrow\] intensive paddock maintains fixation due to lower vegetation cover (i.e. plant heights)
\[\Rightarrow\] extensive paddock, decline of fixation due to a high vegetation cover which is more susceptible periods of water stress.
8 automated chambers + IRGA
Results: Effects of clover density on N\textsubscript{2}O emissions

- N\textsubscript{2}O emissions peak at after cuts
- N\textsubscript{2}O emissions ↑ with low clover content
- competition plant/soil for N depending on clover density

2010 experiment: Impact of cutting frequency on N\textsubscript{2}O emissions

(Klumpp & Bloor et al. 2010)
**Eddy covariance (Los Gatos)**

- **Closed path fast methane analyser (Los Gatos)**
- **Method validation:**
  - SF$^6$ tracer technique
  - Backward-Lagrangian stochastic dispersion model
  - Gaussian Plume dispersion modelling
  - Turbulent flows

**CH$_4$ Flux from animals**
Method: CH₄ - SF₆ Tracer

- Good agreement between methods at 10-30 m distance
- Dilution of CH₄ signal at 30-50m distance
- Verification with atmospheric dispersion models

(Tallec & Klumpp et al. en préparation)
Method: CH$_4$ – Gaussian Plume dispersion

Dispersion observed
Dispersion simulated

Total sim 10162
Total obs 7029

Dispersion observed
Dispersion simulated

Total sim 436
Total obs 314

Wind direction
Wind speed > 2 m/s

FMA & Wind speed and wind measurement

CH$_4$ release

Transect 80m

Tube 0m

6.6m
Pasture Simulation Model (PASIM)

- Process-based ecosystem biogeochemical model
- It simulates fluxes of carbon, nitrogen, GHG gases, water and energy at the soil-plant-animal-atmosphere interface for managed grasslands at the plot scale
Modelling of grassland / livestock ecosystems

Pasture Simulation Model (PASIM)

Territory

ORCHIDEE (LSCE)

Farm

FarmSim (INRA-EGC, CIRAD)

Plot / forage system

Scale of change
Structure of the farm model FARMSIM

FARM SYSTEM

Module 1: Farm structure
Module 2: Herd
Module 3: Grazing systems
Module 5: Fertilis. & Cutting
Module 6: Crops management
Module 7: Feeding systems
Module 8: Waste managem.
Module 9: Energy consump.
Module 4: Housing

IMPORTS / EXPORTS

PASIM

CO₂, N₂O, CH₄

CERES

CO₂, N₂O, CH₄

IPCC

N₂O, CH₄
Thank you